Microcontroller Control Thermoelectric heating and Cooling System using TEC1-12706

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ABSTRACT

Nowadays microcontroller based automatic temperature (heating and cooling) control system is designed and constructed for the drinking-water. The main function of heating and cooling are done by thermoelectric module TEC1-12706. The PIC 16 series, PIC16F887 is used as the main controller of the control system which decides the water temperature based on ds1820. It is also intended to design a control system for a home appliance simply and to maintain and upgrade easily. The development of software for this control system is designed by using the MickroC Pro for PIC software.

KEYWORDS: Thermoelectric module, ds1820, PIC16F887, MickroC

I. INTRODUCTION

Rising The energy efficiency of thermoelectric refrigerators and water dispenser, based on currently available materials and technology, are still lower than its compressor counterparts. Although the physics of thermoelectric cooling have been understood for many generations, the arrival of suitable Peltier modules, ready to be designed-in to commercial electronic products, is a relatively new phenomenon. Many new and innovative applications for Peltier modules are expected to emerge as designers gain familiarity with the products and design techniques. The thermoelectric module is used as a solid heat pump between two streams as a solid heat pump between two streams of water. The cold stream of water acts as a heat sink while the hot stream of water acts as a heat source.

The aim of the system is developed by circulating water throughout the vest with the help of thermoelectric, heat exchanger and measuring the internal temperature of the suit with the help of microcontroller technology. The microcontroller will do the computing task and the software will compare the value of current temperature and the reset point values. It will send the data to LCD for displaying it. The data will also be sent to the computer where the operator will also be able to monitor the whole process. Then, the signal will be passed to the relays to On-Off the heater or cooler for maintaining the correct temperature. And the microcontroller is the main control unit of the system. This work will solve the desired of people who want to control the temperature of the drinking-water.

II. LITERATURE SURVEY

A. Thermoelectric Module

The first important discovery relating to thermoelectricity occurred in 1823 when a German scientist, Thomas Seebeck, found that an electric current would flow continuously in a closed circuit made up of two dissimilar metals provided that the junctions of the metals were maintained at two different temperatures. The Peltier effect was discovered in 1834 by a French watchmaker and part time physicist Jean Charles Athanase Peltier. Peltier found that the application of a current at an interface between twp dissimilar materials results in the absorption/release of heat as seen in Figure 1. At the subatomic level, this is a result of the different energy levels of materials, particularly n and p type materials. As electrons move from p-type material to n-type material, electrons jump to a higher energy state absorbing energy, in this case, heat from the surrounding area. The reverse is also true. As electrons move from n-type material to p-type material, electrons fall to a lower energy state releasing energy to the surrounding area. The principle of peltier effect is the inverse of the principle of see beck effect [1].

B. Working Principle Thermoelectric Module

A typical thermoelectric module is composed of two ceramic substance that serve as a foundation and electrical insulation for P-type and N-type Bismuth Telluride dice that are connected electrically in series and thermally in parallel between the ceramics. The ceramics also serve as insulation between the module internal electrical elements and a heat

sink that must be in contact with the hot side as well as an object against the cold side surface.

The TEM operating working principle is based on the Peltier effect. The Peltier effect is a temperature difference created by applying a voltage between two electrodes connected to a sample of semiconductor material. One of the TEM sides is cooling and the other side is heating [2].

C. TEC1-12706 Thermoelectric Peltier Cooler

A thermoelectric cooling module (TEC Peltier cooler TEC1-12706) is an electronic semiconductor component that functions as a small heat pump. By applying a DC power source to a TEC, heat will be transferred from one side of the module to the other. This creates a cold and warm side. They are widely used in industrial areas, e.g. computer CPUs, CCDs, portal refrigerators, medical instruments, etc.

Thermoelectric cooling TEC1-12706 uses the Peltier effect to create a heat flow between the junctions of two different types of materials. A Peltier chiller, heater or thermoelectric heat pump is an active solid-state heat pump that transfers heat from one side of the appliance to the other, with electrical energy consumption, depending on the direction of the current. Such an instrument is also called a Peltier device, Peltier heat pump, solid state refrigerator or thermoelectric cooler (TEC). They can be used either for heating or for cooling (refrigerator), although in practice the main application is cooling. It can also can be used as a temperature regulator that heats or cools.

The TEC1-12706 40x40mm Thermoelectric Cooler 6A Peltier Module is the simple application of Peltier Thermoelectric Effect as shown in figure 1. The module features 127 semiconductor couples in the area of 40mmx40mm which very effectively cools and heats up to 90°C.

Thermoelectric coolers also are known as TEC or Peltier Module create a temperature differential on each side. One side gets hot and the other side gets cool. Therefore, they can be used to either warm something up or cool something down, depending on which side use.

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This phenomenon involves heating or cooling of the junction of two thermoelectric materials (bismuth and telluride) by passing current through the junction. During operation, direct current flows through the module causing heat to be transferred from one side to the other. Thus, it creates a cold and hot side. If the direction of the current is reversed, the hot and cold sides are changed. Its cooling power can also be adjusted by changing its operating current [3].

Figure1. TEC1-12706 Thermoelectric Peltier Cooler

III. THE PROPOSED SYSTEM

This paper focuses on water heating and cooling using thermoelectric theory. It is easy to contrast the water dispenser and cooler. It is based on material theory of elements. The thermoelectric theory is applied to implement the module that is call politer module. The market has many modules but the TEC is commonly used. The module has two sides: cool and heat. The block diagram of the proposed system is as shown in figure 2. In this system there is two sections: software and hardware. In the hardware, the microcontroller is used as the main controller in this system. The PIC 16F887 is used in this system. And other compontes required such as temperature sensor, relay, and switch, power supply and thermoelectric. In this system operation is working as the software as user programmed. So the software is required to operate the desired operation with microcontroller.
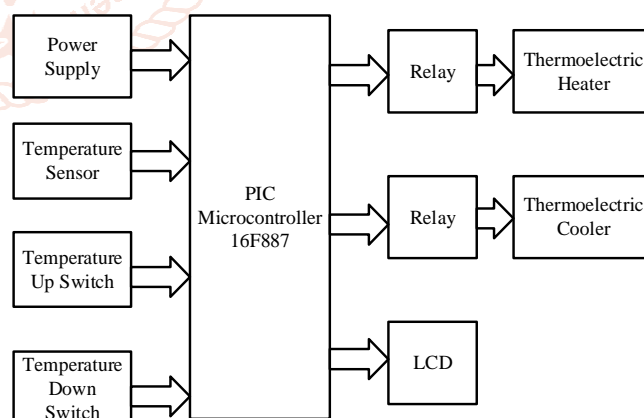

Figure2. Block Diagram of Water Heating and Cooling System using PIC

The above system consists of PIC for controlling process. The PIC is interfaced with LCD display, relay, temperature sensor and thermoelectric plate.

IV. IMPLEMENTATION OF THE PROPOSED SYSTEM
A. Software Implementation
The first thing which is needed to write a program for the microcontroller which understands the programming language such as C or Mikro C. In this system, MikroC Pro for

PIC is used. The operation of system is implemented in program for PIC as shown in figure 3.

B. Hardware Implementation

The PIC microcontroller, PIC16F887 is the main controller and the power source of the control system is applied from the switching mode power supply (SMPS). The switching mode power supply is regulated to the 5 VDC by using the LM7805 regulator. Because of the controller is needed the 5VDC. The 62x2 LCD is used to display the temperature of the system. The output of the system the thermoelectric Peltier plates are used. But the PIC16F887 cannot control these devices directly so the relay and its driver circuits are designed to control the thermoelectric Peltier plates. The overall schematic diagram of the system is described in figure 4.

Figure3. Process Flowchart of the System

The sensor, Water Tank and Thermoelectric Module are assembled as shown in figure 5.

Figure4. Overall Schematic Diagram Of The System

Figure5. The Assembled Water Tank and Thermoelectric Module

V. SIMULATION AND EXPERIMENTAL RESULTS

The simulation of this thesis is done by using the Proteus software. The user program is developed MikroC compiler that is translated hex file to program PIC16F887.

The operation of the system depends on these two temperatures that are user defined and sensor value. When the input set temperature is zero and the temperature from sensor is 36°C, the cooling process is needed. To activate the cooling process the relay for cooler plate is work. The cooling process is work according to the figure. 6 in simulation process.

Then the input temperature is set as the 47°C from the input buttons of the simulation. The set temperature is greater than the temperature from the sensor, so the heating system is needed to work. The heating side is connected with the relay and this relay is needed to work. This heating system work correctly in simulation which is described in figure.7.

If the defined value is equal the sensor value, the led will be turn on. In this situation, both heating and cooling are turn off as shown in figure 8. Therefore, this system can be constructed in hardware safely.
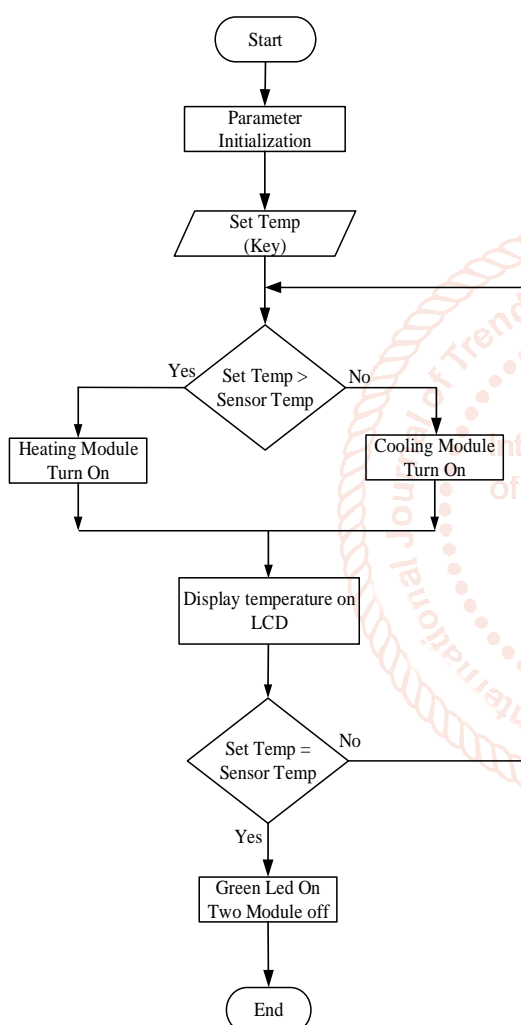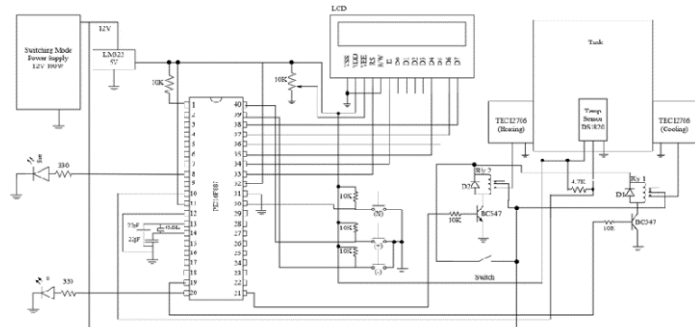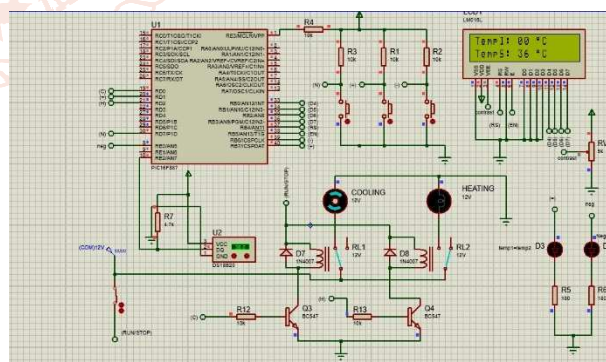

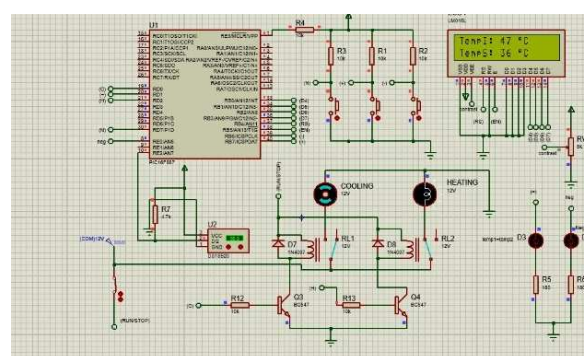**Figure 6. Cooling Process in Simulation**

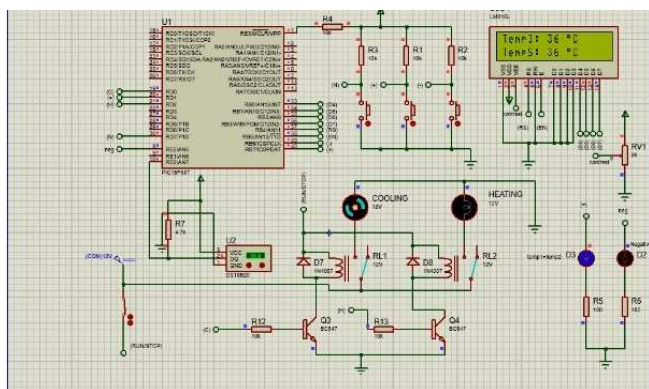**Figure 7. Simulation of Heating Process**

Figure 8. The Defined Temperature is Equal to the Sensor Value

Then the proposed system's circuit is tested with the programmed PIC16F887 microcontroller which is shown in figure 9. In this figure, the user defined temperature is 0°C and the temperature from the sensor vale is 28°C which is the normal water temperature. At this time, the cooling side is activated and the cooling process is working as the result.

And then the 32°C is inputted to the controller by using the input buttons. These buttons are work correctly and the LCD display also show the temperature changing which is shown in figure 10. The input temperature is greater than the sensor value so the heating process is needed to carry out. As the result the cooling process is stopped and the heating process is started by switching on the relay for the heater side. And the sensor temperature is also increased slowly.

The user defined temperature is set as the 19°C and test the cooling process of the system and the resultant data for this process is recorded. According to the results, the time to cool the water from 28°C to 19°C take about 3 hours. This is not bad as a result but it should be faster. Although the time is also depended on the amount of water. The testing amount of water is about 6 liters. According to this amount of water, the result is a good result. To reduce the cooling time, the amount of water can be reduced or the tank should be the steel tank because of the steel can conduct the heat easier than the plastic tank. The results are shown in figure 11 and table 1.
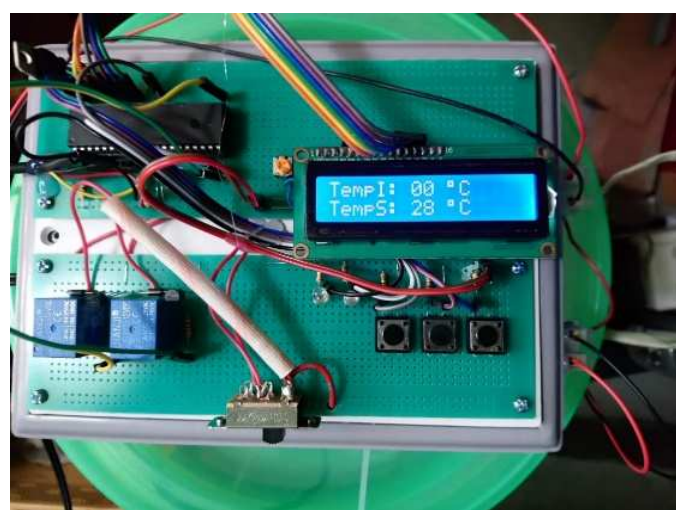

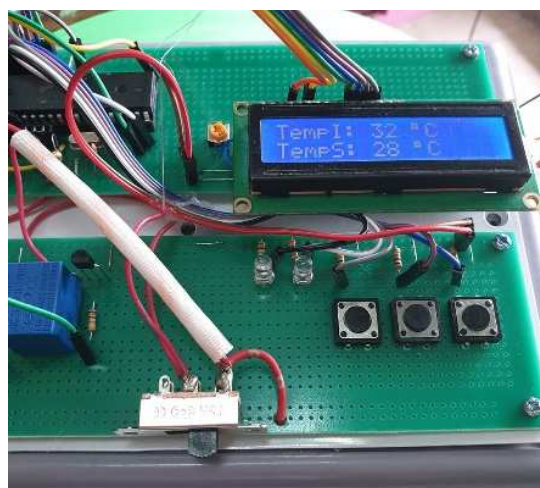**Figure 9. The Circuit is Implemented**

Figure 10. The Heating Process is Carried Out

Figure 11. Cooling Process Results

Table 1. Resultant Data for Cooling Process

Desired temperature	Sensor value	Time
19	28	9 min
19	27	13min
19	26	21 min
19	25	25min
19	24	21min
19	23	20min
19	22	22min
19	21	22min
19	20	19min
19	19	21min

Then the heating side is tested and record the results according to the figure 12 and table 2. The 38°C is inputted and watching the heating side process. The taken time for 10°C heating time is about 2 hours.

Table2. Resultant Data for Heating Process

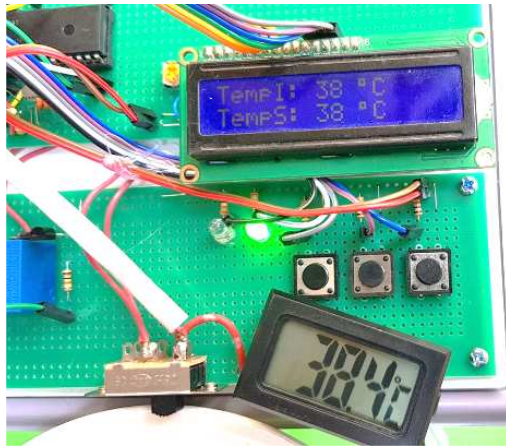| Desired temperature	Sensor value	Time
38	28	16min
38	29	16min
38	30	10min
38	31	15min
38	32	13min
38	33	20min
38	34	22min
38	35	21min
38	36	19min
38	37	21min

Figure 12. Heating Process Results

In this system, the heating and cooling is used thermoelectric that called Peltier module. This effect of the system is clean the environment because there is no use the gas for water cooling and heating. The half hour needed to decrease the about one degree Celsius.

VI.   CONCLUSION

This research work explores the construction of a home appliance and the systematic approach of temperature control system design using the thermoelectric module TEC1-12706 with PIC. The PIC 16 series, PIC16F887 is used as the main controller of the control system. It is also intended to design a control system of a home appliance using thermoelectric module TEC1-12706 easily.

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